TABLE 1.—*Evaporation and related factors*

SAN JUAN, P. R. (1917-1930)

[Lat. 18° 29′ N., long. 66° 7′ W.]

	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Evaporation	5.558	5.533	7.615	7.848	7.743	7.427	8.143	8.053	6.615	5.870	5.081	5.462	80.948
Wind mileage	3,975	3,397	4,089	3,567	3,401	3,407	4,322	3,801	2,561	2,106	2,366	3,723	40,716
Rainfall (inches)	4.11	3.15	2.90	3.32	5.12	4.65	5.74	5.50	5.95	5.41	6.37	4.64	56.86
Mean temperature	74.5	74.5	75.0	76.2	78.6	79.3	79.6	80.2	80.2	79.6	78.0	75.9	77.6
Vapor pressure deficit	.158	.160	.211	.230	.248	.245	.237	.248	.237	.218	.198	.177	
Sunshine hours	218	224	254	252	249	259	269	288	237	239	218	228	
Evaporation computed [1]	7.025	6.322	10.049	9.591	10,097	9.611	11.361	11.036	7.806	6.500	6.256	7.399	103.053

[1] From equation of Fitzgerald.

ST. CROIX, VIRGIN ISLANDS (1920-1930)

[Lat. 17° 46′ N., long. 64° 45′ W.]

	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Evaporation	4.779	5.005	6.535	7.202	7.241	6.909	7.249	7.098	6.141	5.731	4.550	4.537	72.977
Wind mileage	1,312	1,046	1,270	1,172	1,230	1,364	1,499	1,302	1,009	820	792	1,082	13,898
Rainfall	2.70	2.10	2.31	1.62	2.40	2.00	3.34	4.35	6.59	5.50	4.72	2.83	40.46
Mean temperature	75.9	75.4	76.0	77.6	79.6	80.9	81.4	81.6	81.1	79.9	78.2	76.6	78.7

KINGSTON, JAMAICA (1924-1930)

[Lat. 18° 1′ N., long. 76° 48′ W.]

	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Evaporation	5.463	4.997	7.020	7.987	7.920	7.289	8.121	7.911	5.457	4.377	3.757	4.324	74.623
Rainfall	0.37	0.69	0.42	0.94	1.78	0.63	1.14	4.39	3.30	6.00	3.25	0.99	23.90
Mean temperature	76.6	76.3	77.4	78.4	80.3	81.4	81.8	81.7	81.1	80.1	79.0	77.2	78.7

THE PIONEER METEOROLOGICAL WORK OF ELIAS LOOMIS AT WESTERN RESERVE COLLEGE, HUDSON, OHIO, 1837–1844

By ERIC R. MILLER

[Weather Bureau Office, Madison, Wis.]

In the spring of 1836 Elias Loomis (1811–1889), who had been a tutor at Yale, was appointed professor of mathematics and natural philosophy in Western Reserve College, one of the institutions acting as hosts for the meeting of the American Meteorological Society at Cleveland in 1930. Western Reserve College had been founded in 1826 at Hudson, Ohio, about 20 miles southeast of Cleveland, as a sort of Yale in Ohio by the Connecticut people who had first settled the region.

Loomis's salary was to be $600 per annum, but there was an economic depression in progress then as now, so that so much of his salary as was not paid in kind remained in arrears, and when he left Hudson the college offered to deed him some of its unimproved lands (**1**). He was allowed to spend the first year of his professorship in Europe, where he attended the lectures of Arago, Biot, Dulong, Poisson, and Pouillet in Paris, and bought apparatus there and in London, but did not have money enough to go to Germany. In the autumn of 1837 he returned to Hudson to teach and investigate for the next seven years. The chief objects of his researches were terrestrial magnetism, auroras, and storms.

Intense interest in storms had been aroused by the publications of Redfield, Espy, Dove, Reid, and Piddington, of whom Redfield and Espy had become involved in a hot controversy over the air circulation in tropical cyclones (**2**). To put the rival theories to the test of experiment, Loomis set about collecting all available data "on the storm which was experienced throughout the United States about the 20th of December, 1836," as the title of his paper runs (**3**). This storm was selected because it occurred within a period recommended by Sir John Herschel for hourly meteorological observations. The extent to which Americans were then cooperating in international meteorology is indicated by all of the phenomena having been recorded hourly at eight stations—Baltimore, New York, Albany, Flushing, New Haven, Gardiner, Montreal, and Quebec. Loomis obtained barometer readings from 27 stations, and other information from stations distributed over most of the country east of the Rocky Mountains, as well as from Bermuda, the West Indies, and from a ship on the Pacific coast.

He mapped this storm at 6-hour intervals, studying the pressure, temperature, wind direction and velocity, and precipitation. The center passed north of all of the observers, but he made a remarkable study of the phenomena of the cold front, of which his paper contains an isochronal map showing how it swept across the country. To illustrate the lines on which he attacked his problem, the following is quoted from this paper:

> But how is it possible for two winds not far separated from each other to blow violently toward each other for hours and even days in succession? Let us make a simple numerical estimate. The wind blew from the northwest at least 40 miles per hour. This gives a progress due east of more than 28 miles per hour, and is fully equal to the average progress of the barometric minimum. The atmospheric wave, then, progressed with not far from this velocity with which the wind was observed to blow, but in order to allow an opportunity for this onward progress, the wind in advance of the wave must retire, and that with the same velocity with which the northwest wave approaches. * * * The conclusion is inevitable that the northwest wind displaces the southeast wind by flowing under it. * * * The southeast current found its escape by ascending from the surface of the earth. Having quit the surface, it might either flow on in its first direction over the northwest current, or it might be driven back over the southeast current, or both of these motions might exist simultaneously. When we come to consider the cause of the rain, we shall be able to judge of the probability of these several suppositions.

After discussing radiation, advection, mixing, and "air suddenly transported into elevated regions" he observes that "the fourth cause of precipitation must be allowed to be by far the most efficient of all."

> Snow and hail (ice pellets?) did fall at nearly all of the northern stations after the northwest wind set in, but the amount was small, much less than must necessarily result if the entire southerly

wind had flowed over the northerly and had its moisture precipitated by it. Still, it seems probable that a part of the southerly wind did continue on its course and produce the snow which was observed to fall. I infer that the current was mainly turned back upon itself so that the moisture as fast as precipitated fell through the lower current still blowing from the southeast. My idea may best be illustrated by a diagram (p. 159).

The diagram anticipates with remarkable exactness the form of a cold current underrunning still, warm air, found experimentally by W. Schmidt (4).

A tornado in northeastern Ohio in February, 1842, started Loomis studying two storms of that month. His paper on these storms (5) created a great sensation at the centennial meeting of the American Philosophical Society in May, 1843, both on account of the light that it shed on the theories of Redfield and Espy, and still more by reason of his invention of the synoptic weather map with isobars and isotherms. He had no means of reducing the barometer to sea level so that he was obliged to draw isobars of equal departure from normal. His paper is illustrated with 13 of these maps, 7 showing the progress of the parent storm of the tornado from February 2 to 5, 1842, the other 6 show the storm of February 15–17, 1842, both at 12-hour intervals. Brandes at Leipzig had constructed similar maps in 1820 and 1826, but did not publish them. Loomis was apparently unaware of the work of Brandes, and is in any case entitled to the credit of first publication.

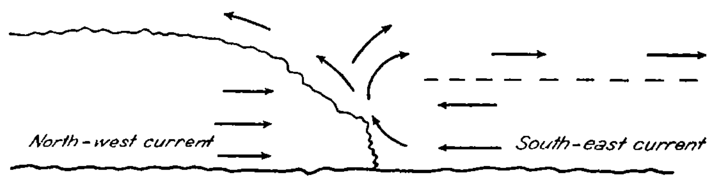
In this paper again, Loomis is concerned with the thermodynamics of ascending and descending air, and quotes the observations and experiments of Poisson, Gay-Lussac, Forbes, Pouillet, Leslie, and especially the experiment of Clement and Desormes which is still repeated by sophomores in the college course in physics to-day. The following quotation (p. 174) shows one of Loomis's applications of the theory:

As the westerly wind pours over the (Allegheny) mountains and descends to the level of the sea it comes under greater pressure, and heat is developed which dissolves the vapor, producing clear sky. Thus clear sky succeeds a storm much sooner on the eastern than on the western side of the mountains.

This paper also contains two anticipations of the Bjerknes Polar Front theory (p. 178). "These oscillations are propagated by the laws of waves." On page 180 he charts the instantaneous directions of the winds in two cyclones and shows that these consist of two streams of air, of which the northwest current revolves in an inflowing spiral around and impinges against the side of the southeast current.

Loomis numbered among his students at Western Reserve College an energetic fellow, Halbert E. Paine, who rose to be major general of Volunteers in the Civil War, was elected to Congress while yet in camp, and afterward was appointed Commissioner of Patents. In the second of these capacities Paine put through Congress in the record time of seven days the act that started our present national weather service.

Loomis went to the University of New York in 1844, where he wrote many of the textbooks that made him famous and wealthy. He succeeded Joseph Henry at Princeton when the latter became the first secretary of the Smithsonian Institution, but Loomis was induced to return to New York the following year and remained



until 1860 when his alma mater, Yale, called him to the professorship that he held the remainder of his life. His Treatise on Meteorology was published in 1868. Beginning 1874 he presented a series of 23 contributions to meteorology to the National Academy of Sciences.

Loomis's prestige was used by Henry to support the extensive meteorological program of the Smithsonian Institution when it was organized in 1847, and by Paine again in 1870 when the meteorological work was initiated under the chief signal officer of the Army, which has developed into the present United States Weather Bureau.

Loomis passed away in 1889 at the age of 78. His fortune of $300,000 derived from his text-books, left to Yale University, was the largest bequest received up to that time by that institution.

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GREAT DUST STORM IN WASHINGTON AND OREGON, APRIL 21–24, 1931 [1]

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SYNOPSIS

A considerable part of Washington and Oregon experienced on April 21–24, 1931, an extraordinary dust storm borne on strong northeast winds that were common to both States, although of greater force in some parts than in others.

A week previous saw the end of a rather protracted wet spell in both States which was succeeded by clear skies very low relative humidity under which the top layers of the soil had dried out very thoroughly so that the strong northeast winds that occurred on the 21st whipped up great quantities of dust from the wheat country and the semiarid parts of the interior and carried westward and southward as a dust cloud of great magnitude that subsequently blew itself out over the Pacific Ocean. The strength of the wind was such as to overcome and blow down frail structures and even great trees. So high winds were quite exceptional for the time and place. Forest and brush fires broke out suddenly over much of the territory invaded by the dust storm; the very low relative humidity and poor visibility made fire suppression very difficult.

The winds subsided during the night of the 22d and 23d and during the daylight hours of the 23d but a smoke pall continued for several days in the territory affected.

The strong northeast winds were due to the presence of a large mass of cool dense air centered over the northern part of the Province of Alberta and especially to the relative position of this cool air mass with respect to one of higher temperature and less density than occupied the northern border States of Idaho, Montana, and the Great Basin. The isobaric chart, Figure 1 shows an isobar of 30.7 inches open to the northward, thus marking the

[1] Somewhat condensed from the original.—Ed.